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Signed Stephen Hordley

Dated 22 September 2003

Patent Form 1/77

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The Patent Office

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NEWPORT

1/77

Request for grant of a patent

The Patent Office

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Newport
Gwent NP9 1RH

1.	Your reference	P31574JED/JAL
2.	Patent Application Number *(the Patent Office will fill in this part)*	0218836.5
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Well-Worx Limited 78 Prince of Wales Road Norwich Norfolk NR1 1NJ 14AUG02 E740779-1 D02481 P01/7700 0.00-0218836.5
	Patents ADP number *(if you know it)*	
	If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom 8444614 001
4.	Title of the invention	"Apparatus and Method"
5.	Name of your agent *(if you have one)*	Murgitroyd & Company
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	165-169 Scotland Street Glasgow G5 8PL
	Patents ADP number *(if you know it)*	1198015

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing (day / month / year)

8. Is a statement of inventorship and of right to grant a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	-
Description	14
Claim(s)	- DMC
Abstract	-
Drawing(s)	16 X16

10. If you are also filing any of the following, State how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent	-
Request for preliminary examination and search (Patents Form 9/77)	-
Request for substantive examination (Patents Form 10/77)	-
Any other document (please specify)	-

11. I/We request the grant of a patent on the basis of this application

Signature MURGITROYD & COMPANY Date 13/08/02.

12. Name and daytime telephone number of person to contact in the United Kingdom: Jamie Allan 01224 706616

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Notes

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Apparatus and Method

This invention relates to apparatus and a method for treating wells, especially but not exclusively for abandoning hydrocarbon-bearing wells.

When wells have reached the end of their useful life, they need to be abandoned. The top of the casing strings must be cut off near the wellhead, whilst ensuring that no further hydrocarbons can leak through the casing strings and into the surrounding area. The bottom of the annulus between the two innermost casings is in communication with the formation. Therefore, if this annulus is not completely sealed, hydrocarbons from the formation could leak out.

According to the present invention there is provided well treatment apparatus comprising a cutting tool; a sealing device to seal a portion of a wellbore; and an anchor means to anchor the apparatus with respect to the wellbore.

Preferably, the sealing device comprises at least one and preferably two annular cup devices typically orientated in the same direction to provide a double seal between the portion of the well beneath the sealing device and the surface of the well.

Optionally, the sealing device comprises two annular cup devices orientated in opposite directions to seal the portion of the apparatus in between the two oppositely orientated devices from the rest of the bore.

Preferably, a first fluid circulation device is positioned between the two oppositely orientated cup devices.

Typically the cup devices can be cup testers or packer devices. A preferred cup device comprises a gas line packer available from Double-E, Inc.

Typically, a further fluid-circulating device is located between the sealing device and the cutting tool. Typically, fluid can be diverted between the circulating devices by dropping a ball/dart into the body of the apparatus.

Optionally, at least one further seal is located beneath the cutting tool, to seal the portion of the bore around the cutting tool from that below the cutting tool. Preferably, the at least one further seal is a cup tester.

Preferably, the cutting tool comprises a jet cut nozzle that is able to cut through casings that line the bore. Preferably, the nozzle is rotatable through 360°.

Preferably, the anchor means is located on the body of the cutting tool.

Preferably, at least one part of the anchor means is laterally extendable. The laterally extendable part of the anchor means typically has a foot for engaging a wall of a casing.

Preferably, the foot has a high-friction casing-contacting surface. Preferably, the cutting tool has three circumferentially-spaced feet, to engage the interior of the casing at circumferentially-spaced locations.

The foot can be mounted on a moveable arm that can be driven by a ram or alternatively at least one of the feet can be static eg provided on the body of the cutting tool, or on an extension of the body.

According to a second aspect of the invention, there is provided a method of treating a well, including the steps of:

inserting cutting apparatus into a casing of the well, the apparatus having a cutting tool, a sealing device to seal a portion of the casing from

the surface of the well, and an anchor means on the body of the cutting tool;

perforating the innermost casing in at least two vertically spaced positions;

sealing the annulus between the vertically spaced perforations; and

severing the casings above the uppermost perforation;

wherein the anchor means is used to anchor the apparatus to the casing when the apparatus is perforating the casing and/or injecting fluids.

Preferably a fluid is injected into the annulus between the perforations; typically the fluid is water, but in some circumstances cement or other fluids can be used. Typically the annulus between the perforations is sealed with injected cement.

Preferably, the method further includes the step of pressure-testing the innermost casing before the first perforation is made.

Preferably, the method includes the step of pressure testing the annulus between the innermost two casings before the second perforation is made.

Optionally the method may include the step of pressure testing the annulus between the

perforations after the second perforation has been made.

Preferably, the cement or other fluid is pumped into the annulus from between two oppositely orientated cup devices.

Preferably, the method includes the step of pressure testing the cemented annulus before the casings are severed.

An embodiment of the invention will now be described by way of example only and with reference to the following drawings, in which:-

Fig 1 shows a partial cross-section of an abandonment string inserted into a wellbore to be abandoned.

Fig 2 shows a partial cross-section of the abandonment string piercing the 9 5/8" casing.

Fig 3 shows a partial cross-section of the abandonment string making a second, higher cut in the 9 5/8" casing.

Fig 4 shows a partial cross-section of the abandonment string injecting cement into the annulus between the cuts.

Fig 5 shows a partial cross-section of the abandonment string performing a final pressure test on the cemented annulus.

Fig 6 shows a partial cross-section of the abandonment string cutting through all the casing strings at the wellhead.

Fig 7 shows a schematic cross-section of the abandonment string pressure testing the 9 5/8" casing string.

Fig 8 shows a schematic cross-section of the abandonment string making a cut in the 9 5/8" casing and pressure testing the annulus between the 9 5/8" casing and the 13 3/8" casing.

Fig 9 shows a schematic cross-section of the abandonment string making a second cut in the 9 5/8" casing.

Fig 10 shows a schematic cross-section of an integrity check of the cement in the annulus between the two cuts.

Fig 11 shows a schematic cross-section of cement being injected into the annulus between the two cuts.

Fig 12 shows a schematic cross-section of the cement in the annulus between the cuts being pressure tested.

Fig 13 shows a schematic cross-section of the casings being cut near the wellhead.

Fig 14 shows a cross section of three cup testers mounted on two circulating subs.

Fig 15 shows a side view of a cutting tool.

Fig 16 shows a side view of a portion of a cutting tool.

As shown in Fig 1, an abandonment string 10 typically comprises a cutting tool 12, a first circulating sub 14, two oppositely orientated cup testers 16 18, a second circulating sub 20, a third cup tester 22 and drill pipe 24.

An enlarged view of cup testers 16, 18, 22 and circulating subs 14, 20 is shown in Fig 14. Cup testers 16 and 22 provide two permanent barriers between the hydrocarbon bearing formation and the surface.

Optionally, a second cup tester and sub arrangement may be provided beneath the cutting tool 12. This could be useful if the plug 44 in the innermost casing has not formed a perfect seal. As shown in Fig 1, the arrangement could comprise a sub 26, fourth and fifth cup testers arranged back-to-back 28 30, a further sub 32 and a sixth cup tester 34. This cup tester and sub arrangement is inverted as compared with the arrangement above the cutting tool

12, except that the subs 26 and 32 can be ordinary subs instead of circulating subs. It is not necessary to have this entire arrangement; cup tester 28 would be sufficient, or cup testers 28 and 34, if a double seal is required.

The cutting tool 12 is best shown in Figs 15 and 16. It has a rotatable jet cut nozzle 70, which can cut through casing 36. It has pair of anchoring devices 74 that are axially spaced along the body of the tool, to anchor the tool 12 in the casing 36. Each anchoring device 74 has three feet 78 that are circumferentially spaced around the body of the tool 12 and each foot is attached to the body of the tool 12 by a pair of link arms 72 that are each pivotably coupled at one end to an eye on the foot and at the other end to a respective eye on the body. One of the eyes on the body is mounted on a central plate that is driven axially by a hydraulic ram to push the eyes on the body together thereby extending the feet by means of the pivotal connections so that the feet move laterally to contact the casing 36. Fig 16 shows one embodiment of a part of cutting tool 12, which has a foot 78, mounted on a pair of link arms 72. The foot 78 typically has an abrasive outer surface with eg serrations so that there is high friction between the foot 78 and casing 36 when the two are in contact. Fig 16 also depicts an optional second foot 80, which is mounted on an extension 82 of the body of the cutting tool 12. The cutting tool should have at least one extendible foot 78, and optionally at least one other foot 78

or 80, or other high friction casing contacting surface. Typically there are two or three feet 78 each circumferentially mounted on pairs of linking arms 72 which are circumferentially spaced around the tool 12. As shown in Fig 15, more than one plate 74 may be provided.

The drill pipe 24 extends to the surface. Umbilicals also extend from the surface to the cutting tool 10.

The abandonment string 10 is shown inside a wellbore, which has several layers of casing: 9 5/8", 13 3/8", 20" and 30", which are respectively designated by numbers 36, 38, 40 and 42.

In use, when the corrosion cap/temporary abandonment cap has been removed from the well, a drill string with a rock bit is run into the wellbore, to check that it is free of obstructions. The drill string is typically made up of 3½" or 5" drill pipe.

The abandonment string 10 is made up and run into the hole to a depth of typically 100-400 metres (in some cases up to several thousand metres) beneath the wellhead. The top drive is then made up or the string is connected to a circulation device.

The cutting tool 12 in the string is then anchored to e.g. the 9 5/8" optionally below the wellhead by extending the rams 72 so that the feet 78 contact the casing 36. The abandonment string 10 is thus

held fixed relative to the casing 36 by friction between the feet 78 and the casing 36.

As shown in Fig 7, the casing 36 is pressure tested, to check its integrity. This is done by pumping fluid down through the abandonment string 10 and out through an aperture in circulating sub 14. The fluid is constrained within the area bounded by an existing plug 44 (fitted when the wellbore was temporarily abandoned), the cup testers 16, 22 and the casing 36. This tests the pressure integrity of the casing and of the plug 44 and identifies whether there are any fissures through which significant amounts of hydrocarbons can leak from the formation.

Assuming that the casing 36 and the plug 44 do not have any substantial leaks, the cutting tool 12 then cuts two holes 46, 48 in opposite sides of the casing 36, as shown in Figs 2 and 8. It is not necessary to cut two holes; one would suffice, nor is it necessary for the holes to be opposite each other.

A second pressure test is then performed by pumping fluid 50 (e.g. water) through the abandonment string and out through the aperture in circulating sub 14, in the same manner as the first pressure test. The fluid 50 passes out through the holes 46 and 48 and into the annulus 52 between the casing 36 and the casing 38. Some of the fluid 50 may escape down the annulus 52 and into the formation. The rate of pumping is varied so that equilibrium is reached

between the amount of fluid 50 entering and leaving the annulus 52. The equilibrium rate of pumping and pressure are recorded. A typical equilibrium rate might be 2-3 barrels per minute at a pressure of 3,000 pounds per square inch. This test is done to establish a bench mark for the next pressure test. It also establishes the integrity of the casing 38; if there is very low pressure in the annulus 52 after pumping fluid 50 into it, that could indicate leaks in the casing 38 or the cement job. If there is a very high back pressure, which could be caused by hydrocarbons in the annulus/formation, the excess fluid will have to be removed via the string before proceeding.

The anchoring means are then deactivated to release the cutting tool 12 from the casing 36 and the abandonment string 10 is then raised so that the cutting tool 12 is approximately 400-500 feet above the first cuts as shown for example in Figs 3 and 9. The anchoring means are then reactivated so that the cutting tool 12 is re-anchored to the casing 36 by extending the link arm 72 to push the feet 78, 80 against the casing 36. Two cuts 54, 56 are made with the cutting tool 12 in opposite sides of the casing 36 as before. Again, it is not necessary to cut twice; one cut would suffice. In some cases a further pressure test as described previously can be carried out through the newly made cuts 54;56;--but this is not necessary.

The anchoring devices are then deactivated to release the cutting tool 12 from the casing and the abandonment string 10 is lowered down the borehole so that the cup testers 16 and 22 are between the two sets of cuts 46, 48 and 54, 56, as shown in Fig 10. Fluid is then pumped through cuts 46, 48 and into the annulus 52 between the two sets of cuts 46, 48 and 54, 56. If the fluid pathway is open in the annulus, fluid pumped through the string 10 should flow through cuts 54, 56 without significant measurable pressure build up at surface.

The abandonment string 10 is then detached from the casing, lowered and re-anchored so that the first cuts 46, 48 are positioned between cup testers 18 and 22, as shown in Fig 11. A ball or dart is dropped through the abandonment string 10 so that it diverts fluid from the circulating sub 14 . Cement is then pumped down the abandonment string 10. The cement 58 passes out of the hole in circulating sub 20 and into the annulus 52. When no more cement can be pumped in at a reasonable rate and pressure (with reference to the readings taken earlier) this indicates that the annulus between the cuts is well sealed. Alternatively a cement slug of a known volume can be injected into the string and is pumped through the tool 12. The volume of the slug is calculated to create a plug extending the length of the annulus between the cuts 46, 48 and the cuts 56,58. Typically the distance between the first and second cuts is at least 100 feet, and typically an excess of cement (e.g. 2-300%) is used in order to

ensure that the annular cement plug is sufficiently long.

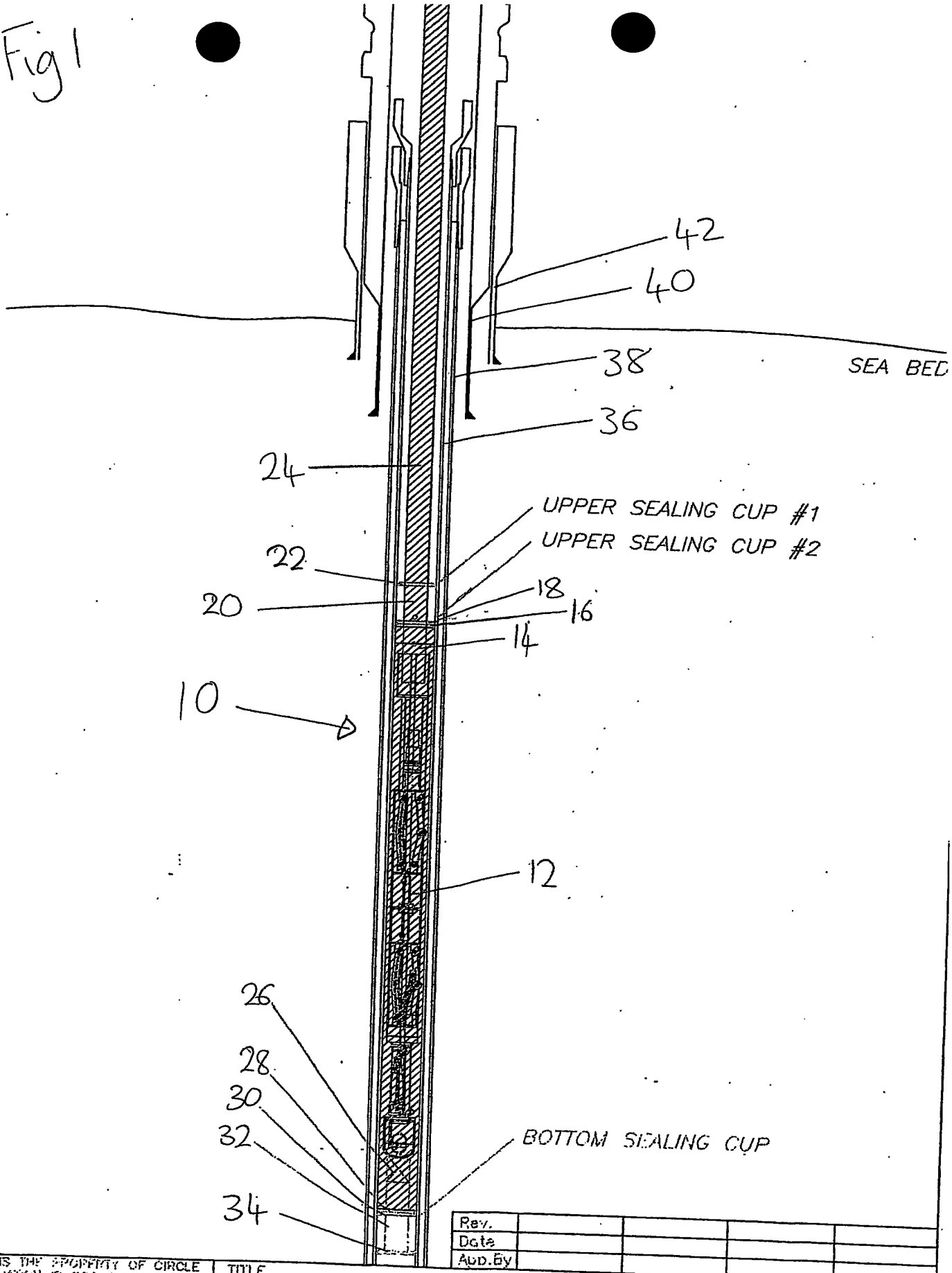
The anchoring devices are then deactivated and the string 10 is pulled out of the borehole before the cement sets. Excess cement that has emerged from the upper cuts 56, 58 is wiped out of the bore by the seals on the tool 12. At this time, the tool is redressed to remove the ball/dart from the circulating sub 14 so that fluid can circulate through the sub 14 once more.

When the new cement is set, the string 10 is run into the borehole again so that the cup testers 16, 22 are in between cuts 46, 48 and cuts 54, 56, as shown in Figs 5 and 12. The annular plug of cement in the section 60 of annulus 52 between the cuts 46, 48 and cuts 54, 56 should now be solid. To test this, fluid (e.g. water) is then pumped down the string 12 and through the hole in the circulating sub 14. If no significant injection of fluid into the annulus 52 is possible, then this proves that the cement job has been successful and that the section 60 of annulus 52 is firmly sealed.

If this is the case, the tool 10 is unanchored, raised and re-anchored so that the cutter of the cutting tool 12 is near the wellhead. The cutting tool 12 is then used to cut through all the casings 36, 38, 40, 42 by continuous cutting while the head rotates around 360°.

Modifications and improvements may be incorporated without departing from the scope of the invention.

Fig 1



Rev.				
Date				
App.By				

TITLE

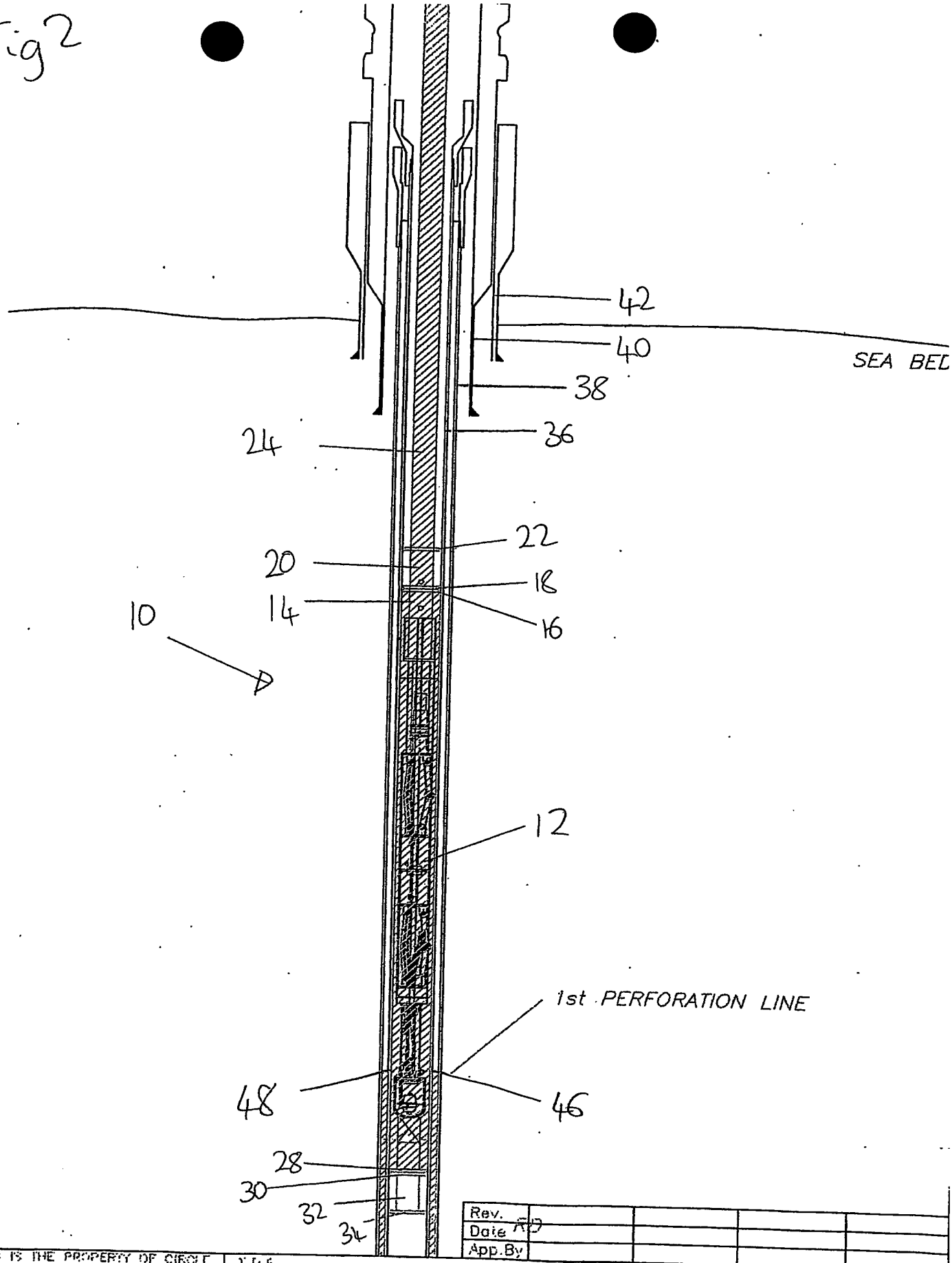
TOOL SHOWN PRESSURE TESTING

CIRCLE TECHNICAL SERVICES LTD.

Aberdeen Tel 01224 [illegible] Fax 01224 [illegible]

DRAWN	KA	SCALE	DRG.No
CHECKED		DATE 04.07.12	[illegible] SHT 1 OF 5

Fig 2



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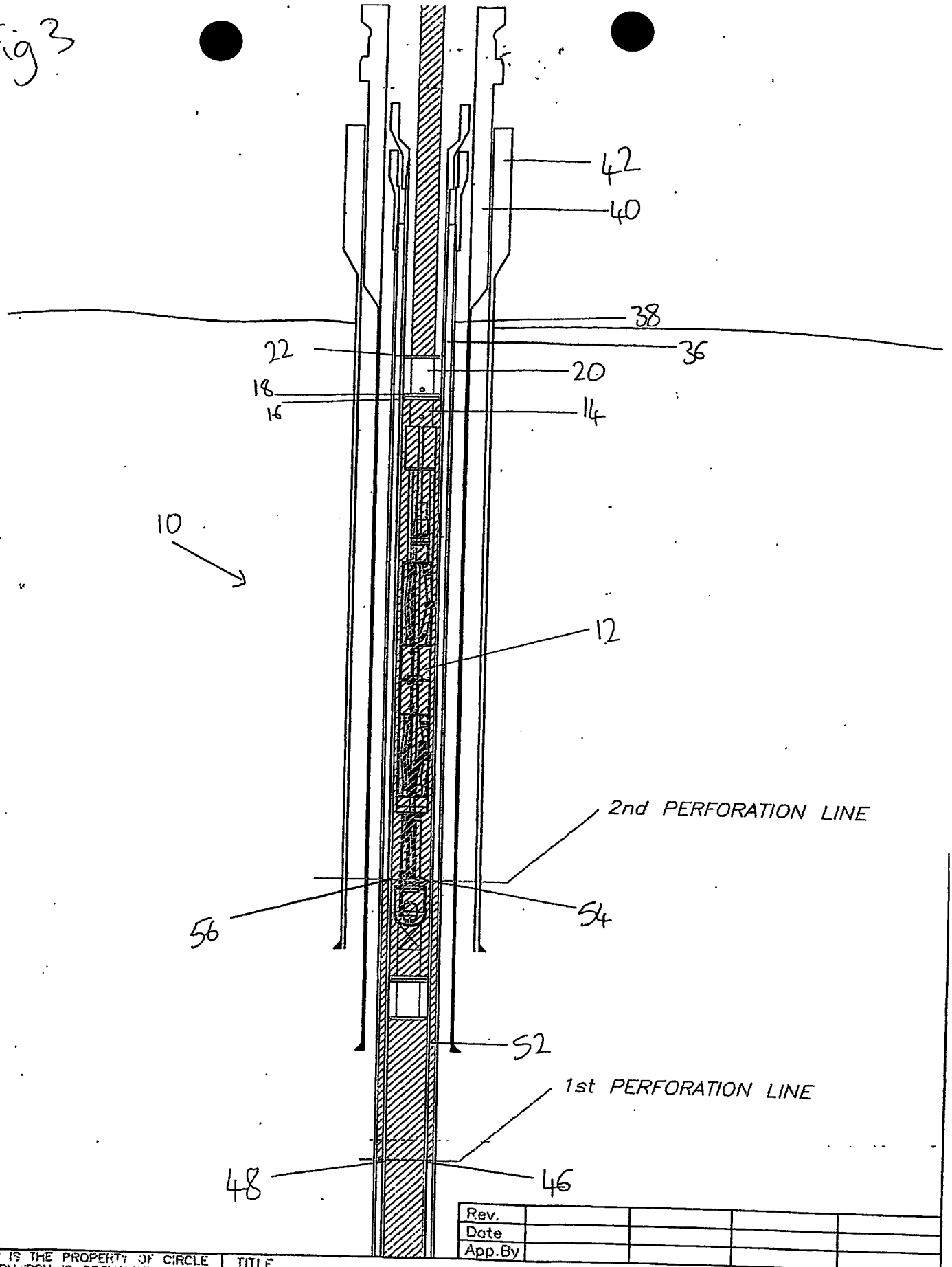
CHECKED	DATE 04.07.02	03-020 Sht 2 of 2	

Fig 3



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Date				
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TITLE: 2nd PERFORATION

CIRCLE TECHNICAL SERVICES LTD.
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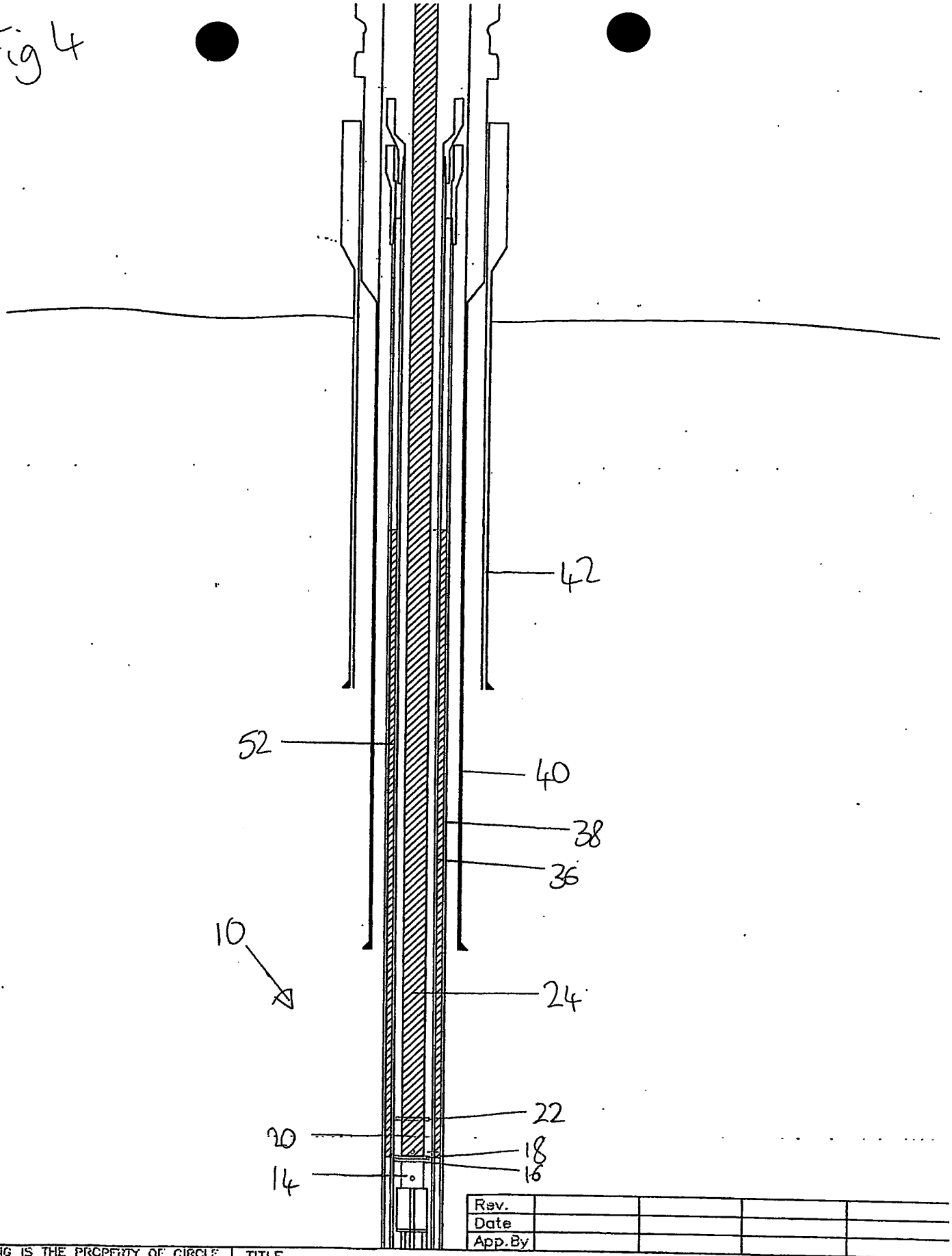
Fig 4



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Date				
App.By				

TITLE

CEMENTING

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775455

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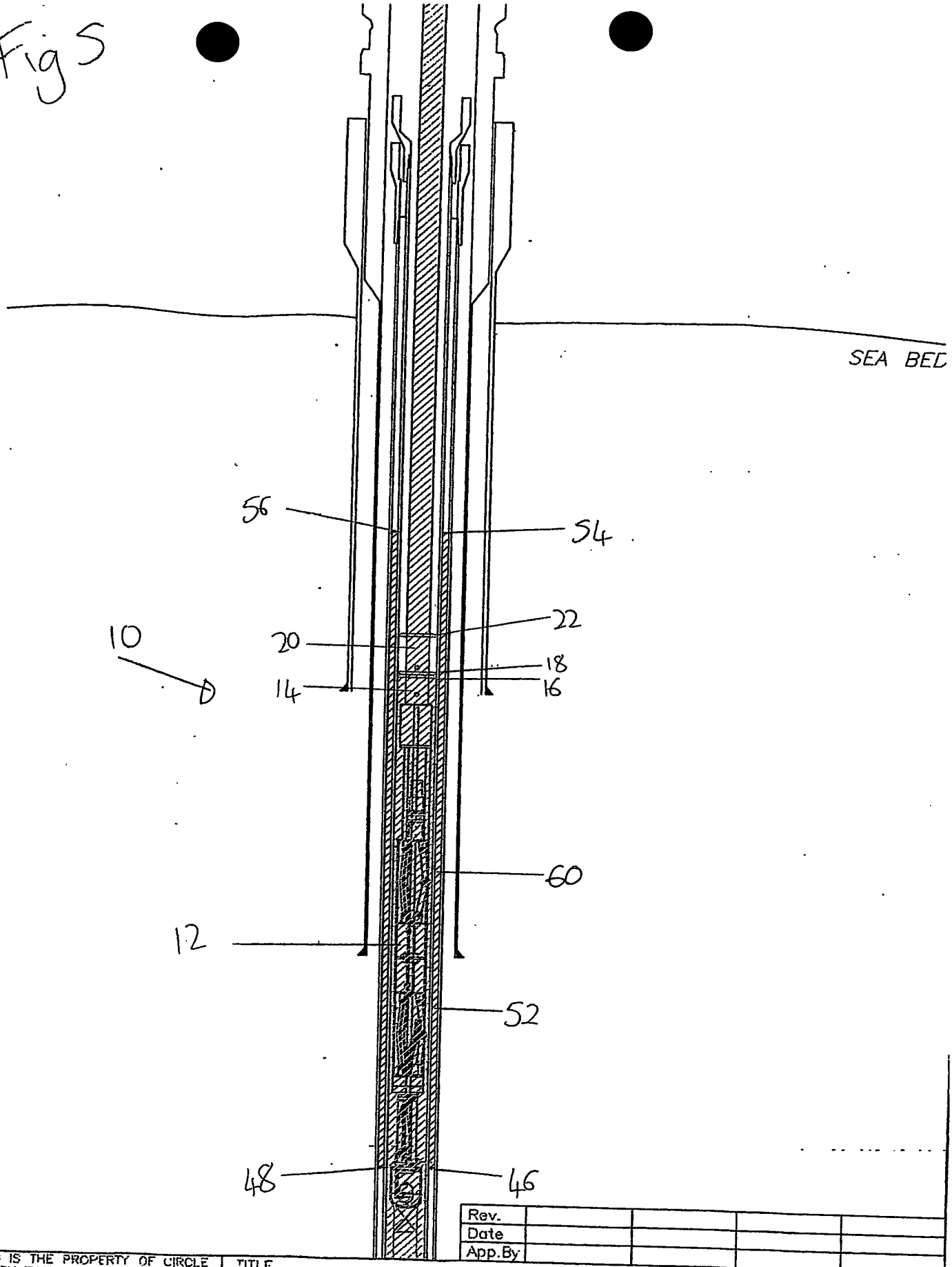
5 Figs



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Date				
App.By				

TITLE

FINAL PRESSURE TEST

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775533

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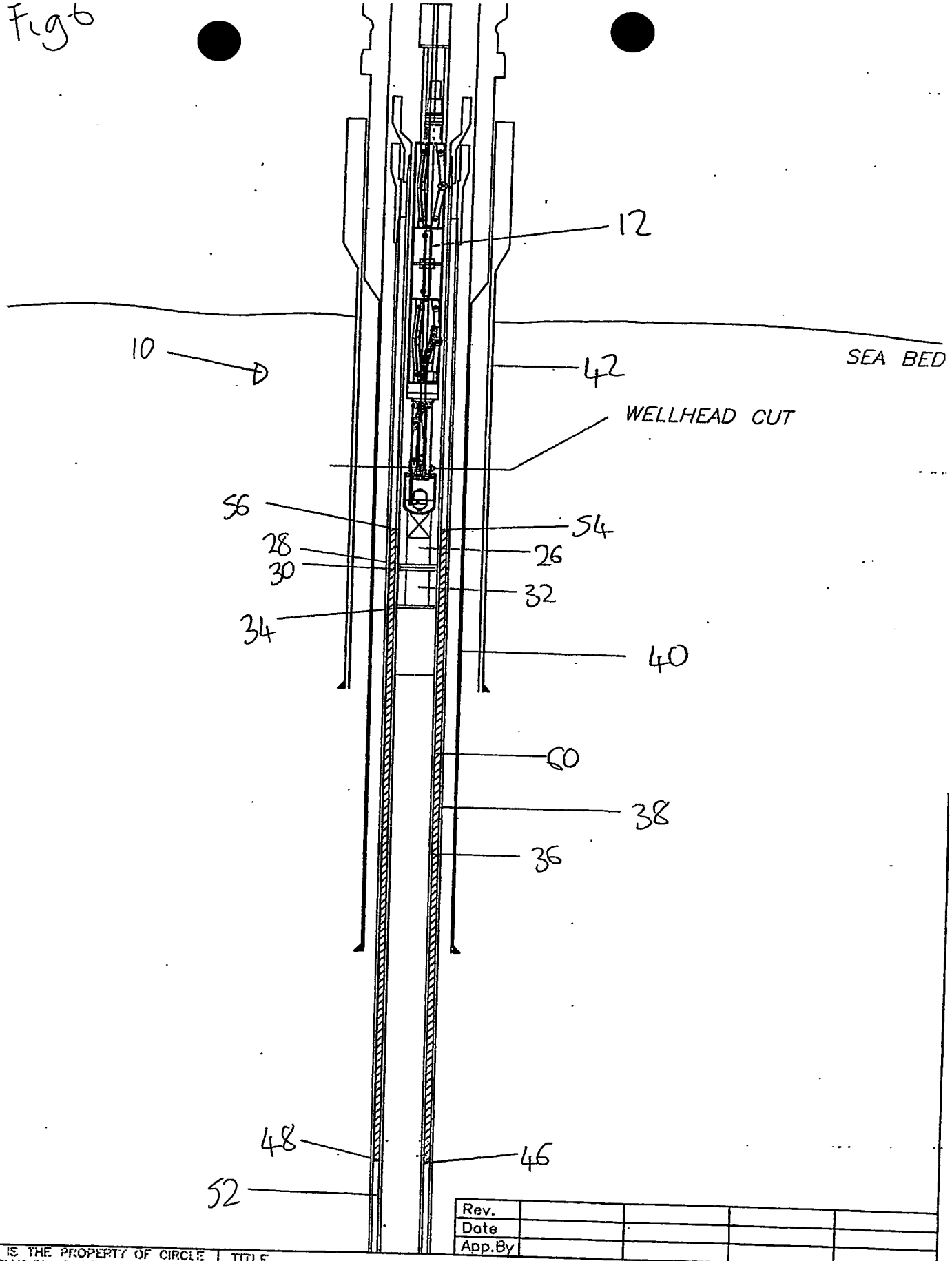
CHECKED	DATE 04.07.02	C3430. sht 5 of 11

Fig 6



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Date				
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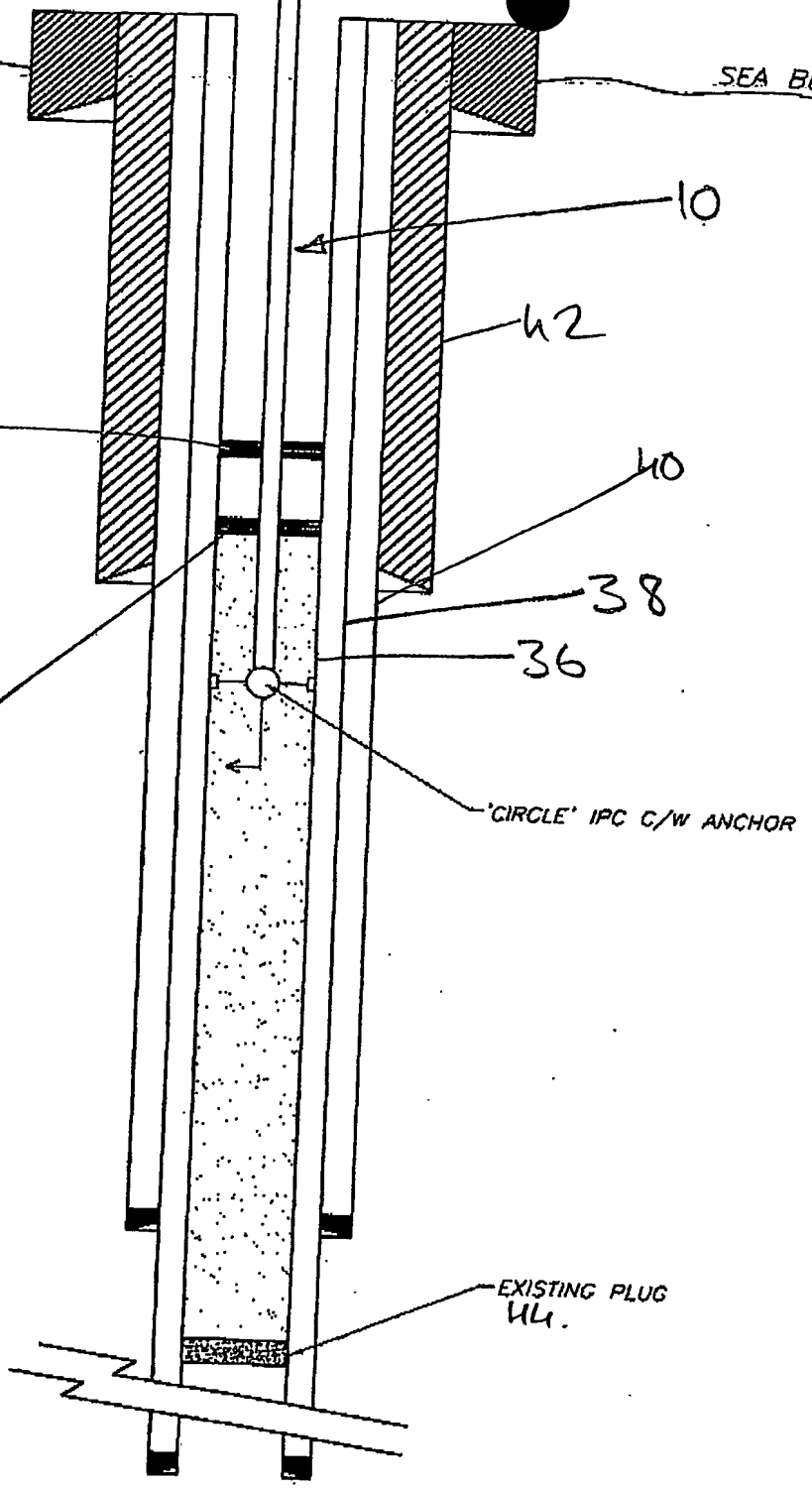
TITLE

WELLHEAD CUTTING

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 778222 Fax 01224 775333

DRAWN KA	CONTRACT 509	DRG.No.
CHECKED	DATE 04.07.02	C3430. sht 6 of 6

fig 7



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Date				
App.By				

TITLE: PRESSURE TEST 9-5/8" CASING

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

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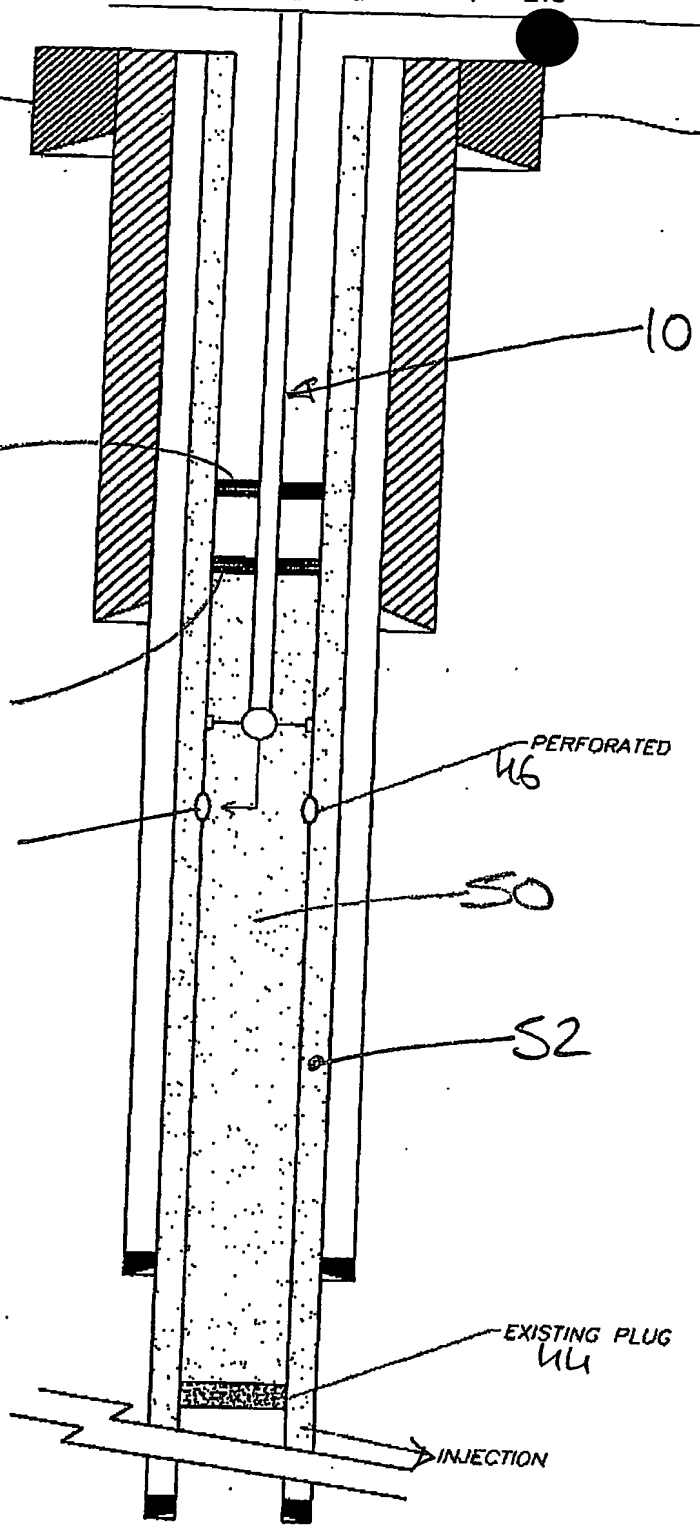
CHECKED	DATE 07.08.02	C3500	

Fig 8



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Date				
App.By				

TITLE: PERFORATE CHECK FOR PRESSURE BEHIND CASING AND ESTABLISH SQUEEZE

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

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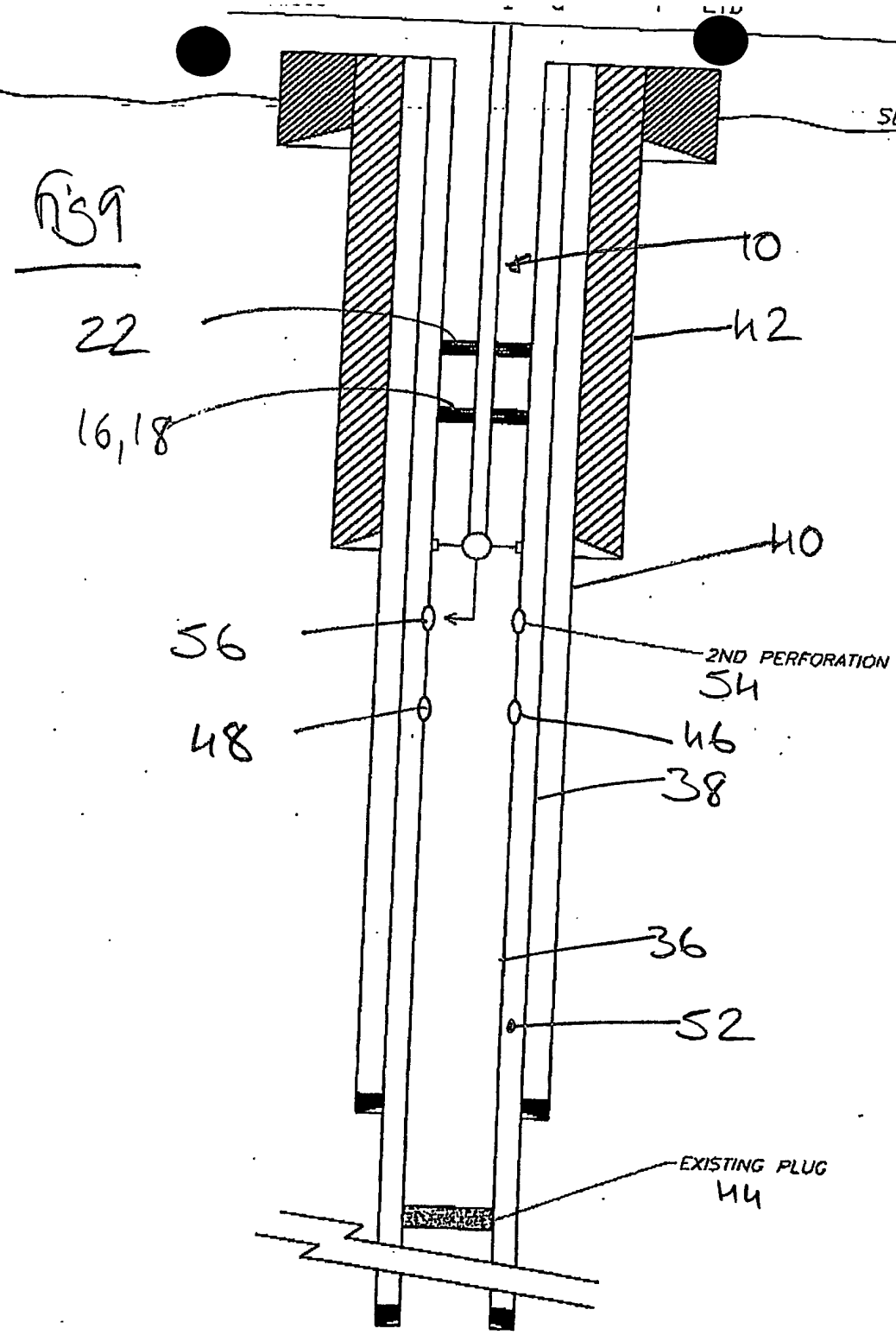
CHECKED	DATE 07.08.02	C3501	

Fig 9



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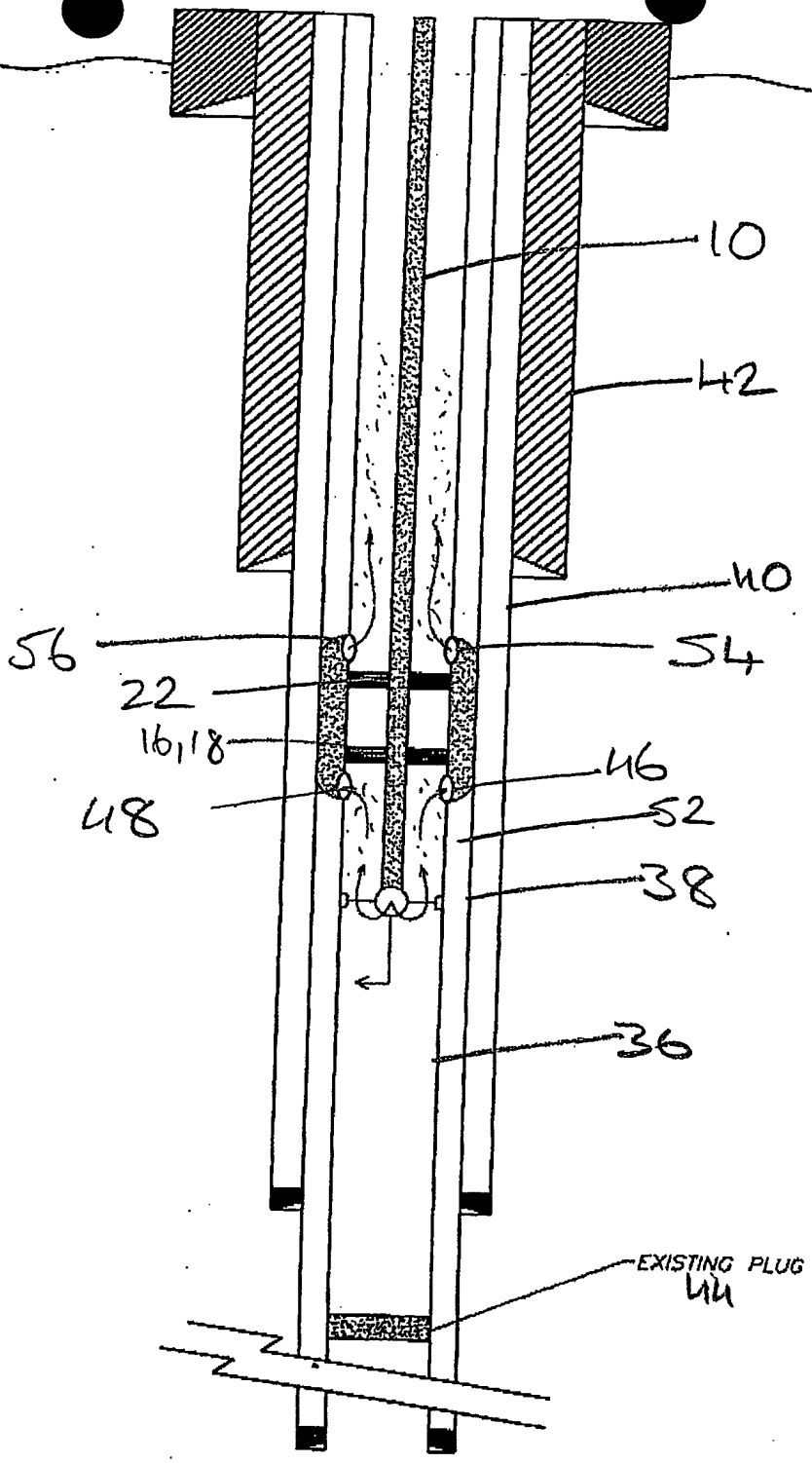
Date				
App. By				

TITLE: MAKE SECOND PERFORATION

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

DRAWN RD	CONTRACT 509	DRG.No.
CHECKED	DATE 07.08.02	C3502

Fig 10



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TITLE: ESTABLISH CIRCULATION BEHIND CASING

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

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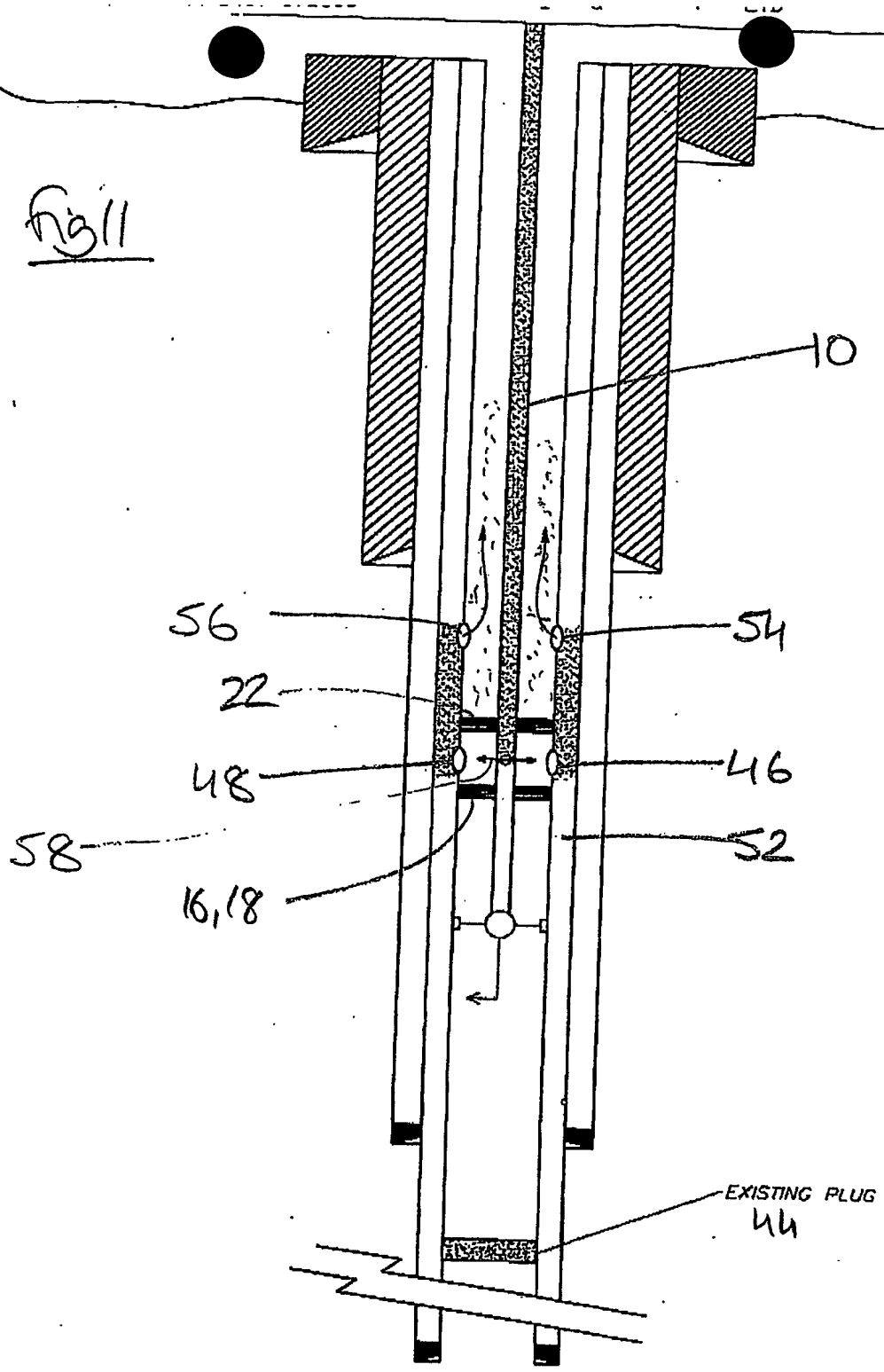
CHECKED	DATE 07.08.02	C3503

Fig 11



Rev.				
Date				
App.By				

TITLE: PLACE CEMENT BEHIND CASING

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

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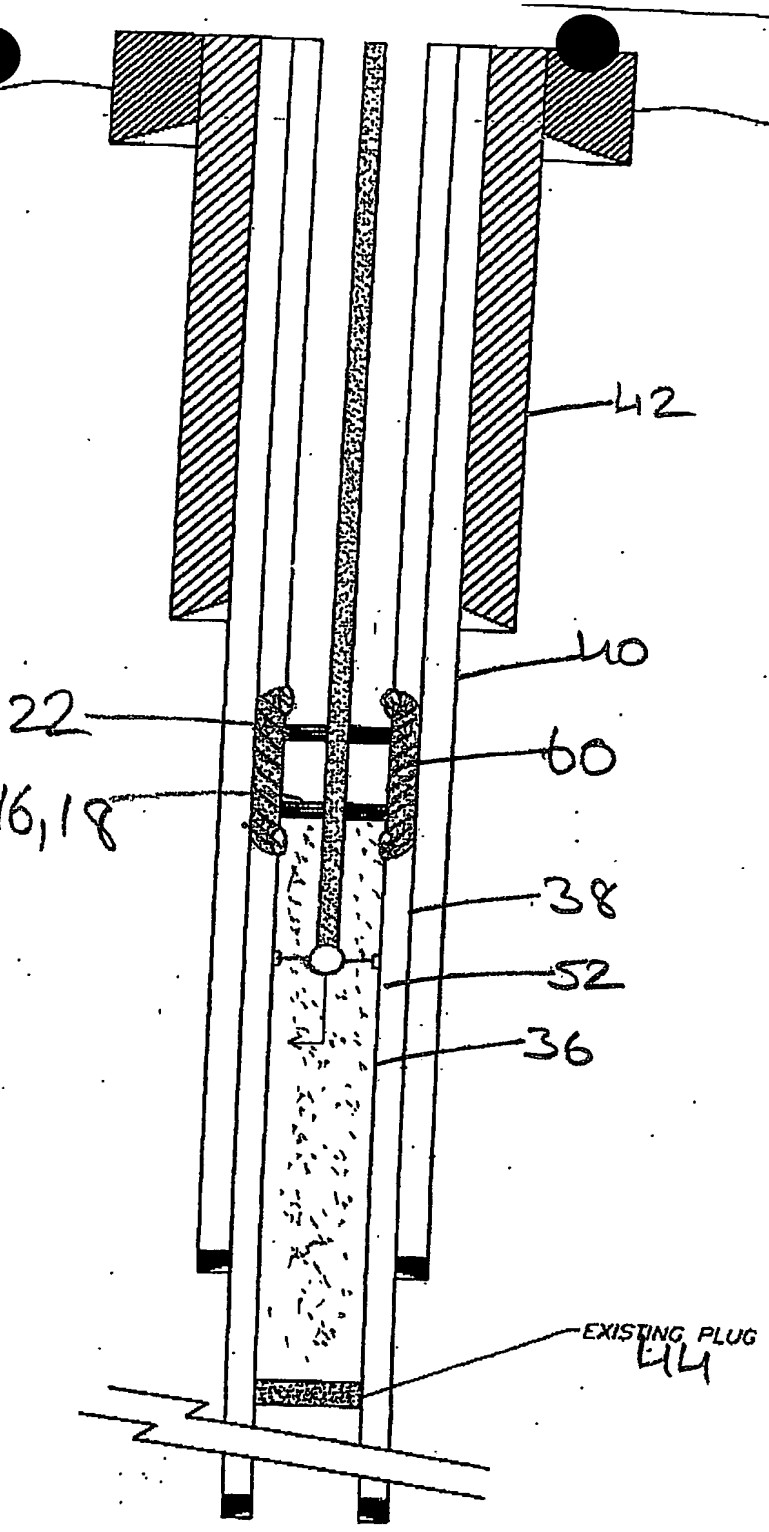
CHECKED	DATE 07.08.02		C3504

Fig 12



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Date				
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TITLE: ESTABLISH CIRCULATION BEHIND CASING

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

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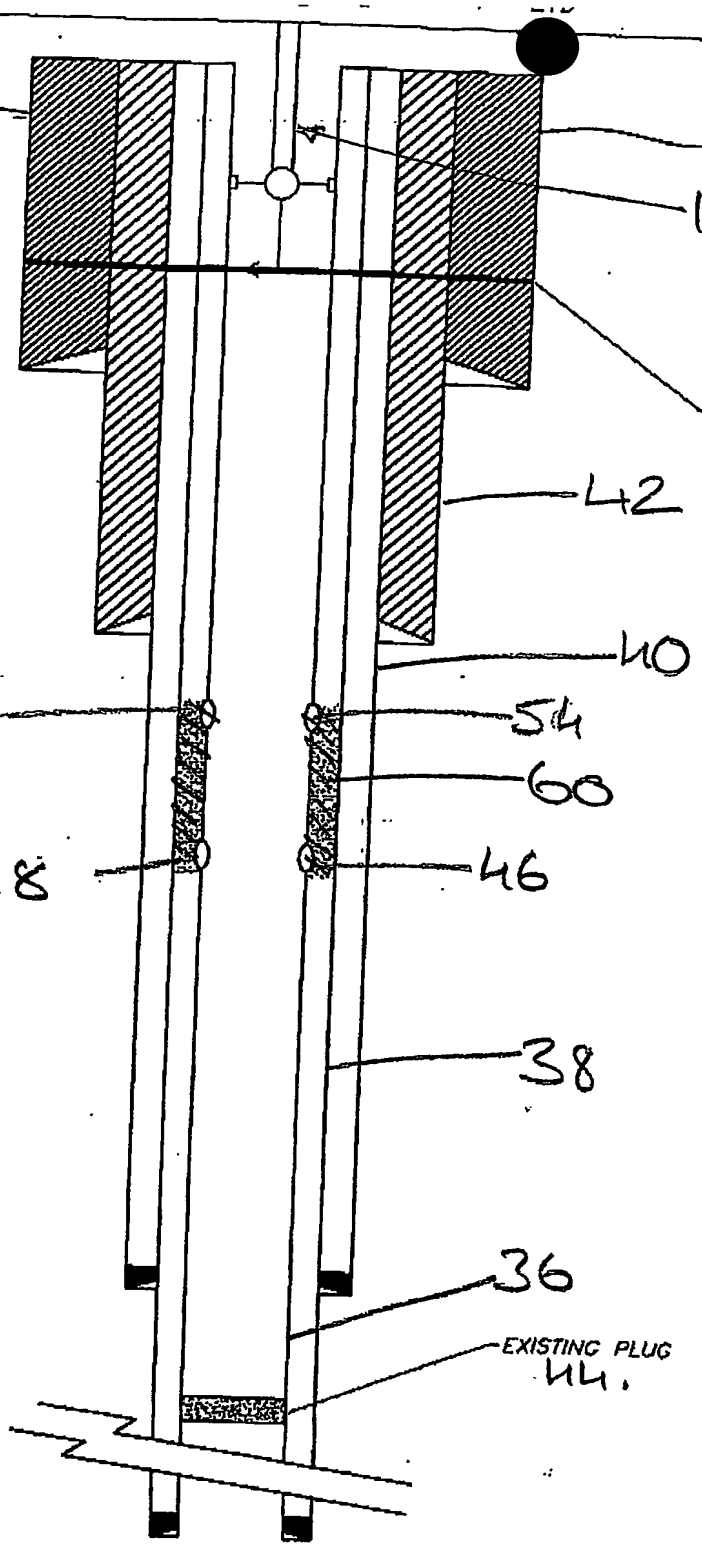
Fig 3



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Date				
App-By				

TITLE: FINAL CUT OF CASING

CIRCLE TECHNICAL SERVICES LTD.
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Fig 14

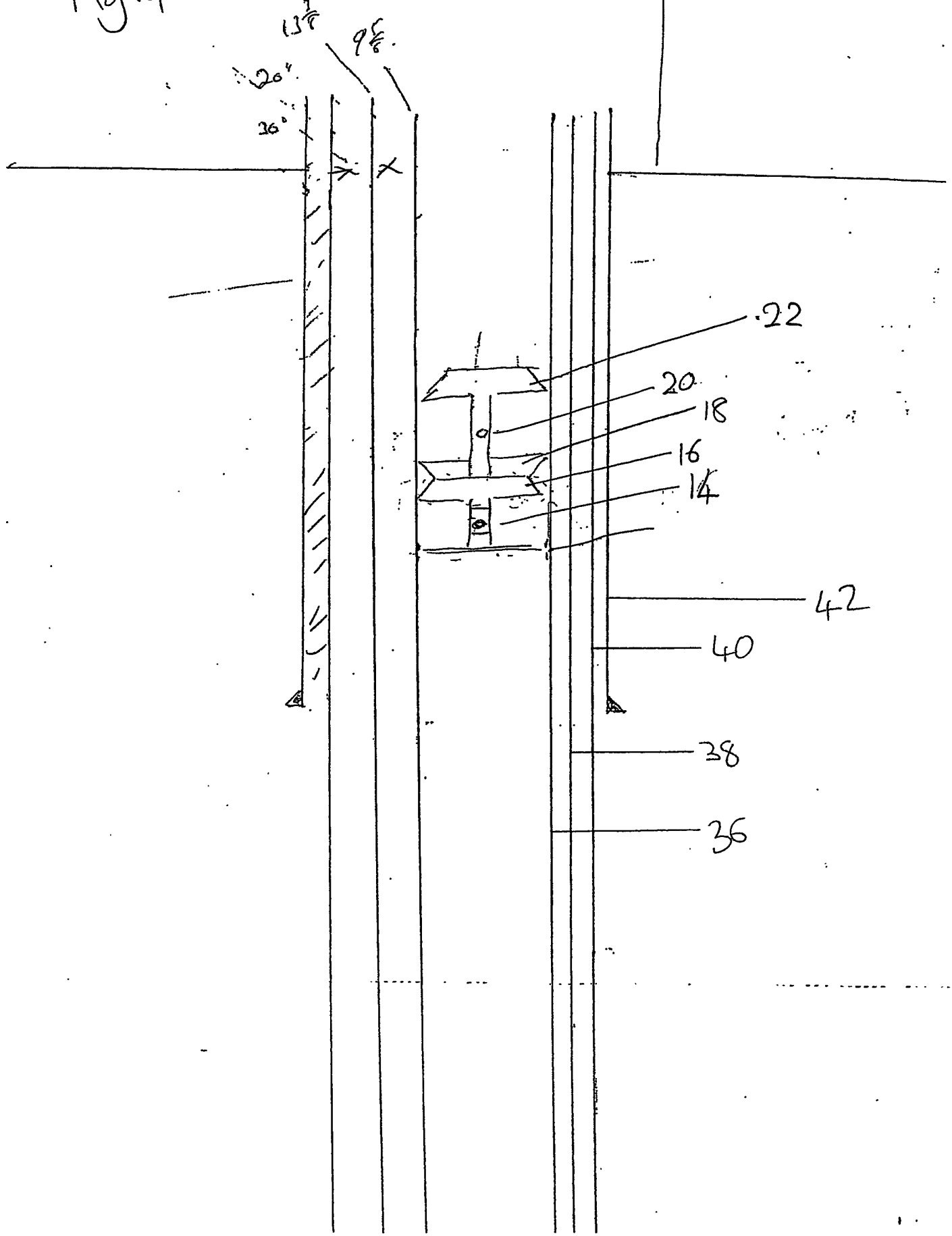
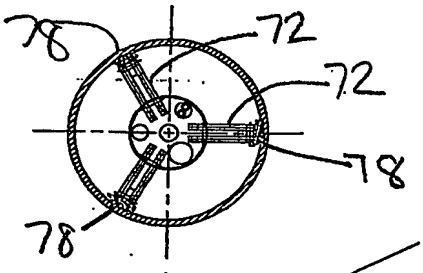


Fig 1S(a)



12

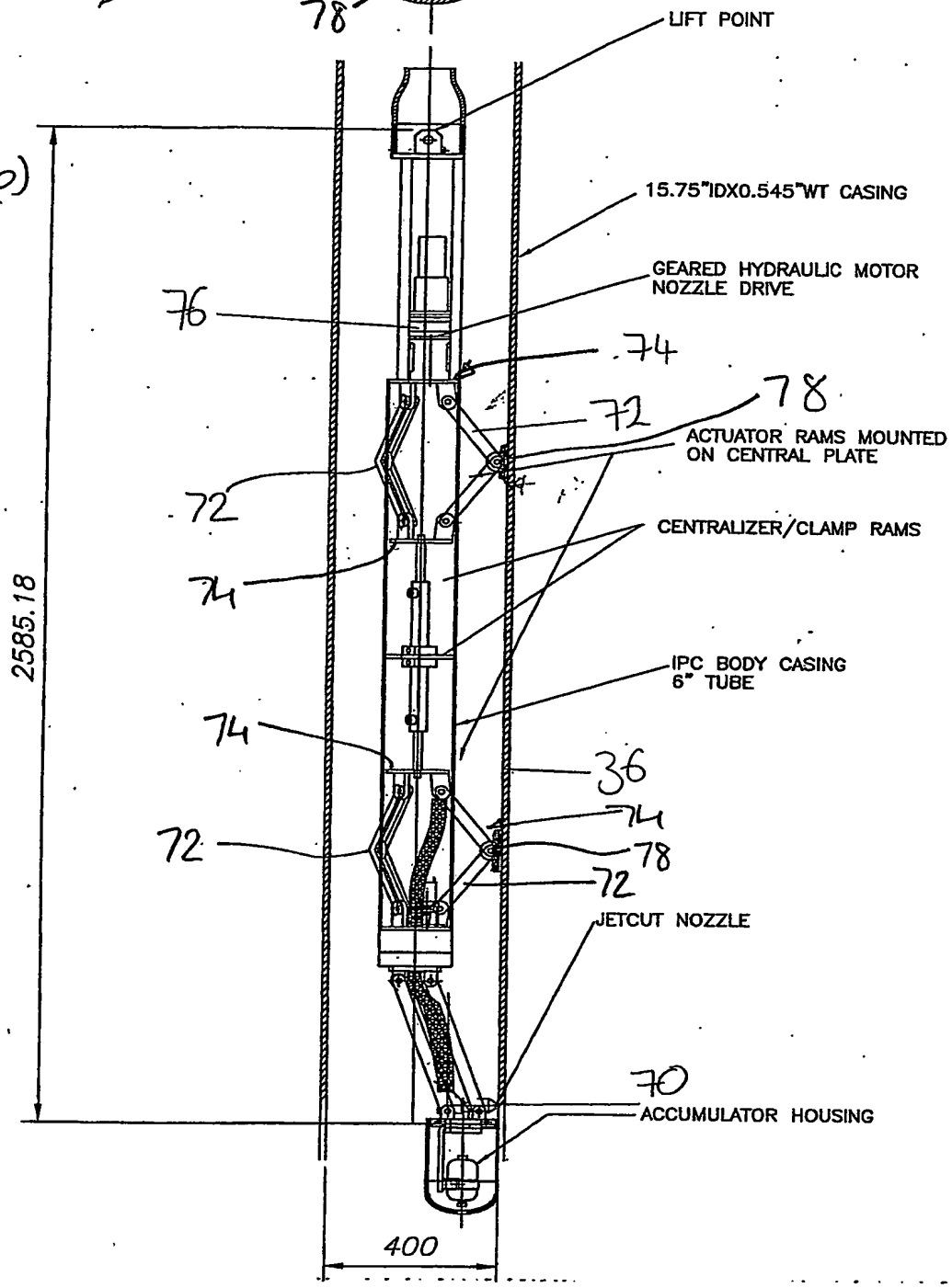


Fig 1S(b)

Issue				
Date				
App.By				

TITLE

Ø215" INTERNAL PIPE CUTTER SHOWN EXTENDED

CIRCLE TECHNICAL SERVICES LTD.
Aberdeen Tel 01224 775222 Fax 01224 775333

DRAWN RD	CONTRACT 486	DRG.No.
CHECKED	DATE 13.09.01	C2816

Fig 16